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	Prepared by(s) Nick Virmani	Supersedes None
	Subsystem/Office Calorimeter	
Document Title **Calorimeter Quality Assurance Activities**		

Gamma-Ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Calorimeter Quality Assurance Activities

and

Implementation Plan

DRAFT

Document Approval

Prepared by:

_____ _____
Nick Virmani Date
CAL Contamination Engineer / QA Manager

Reviewed by:

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Date
CAL

_____ _____
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Approved by:

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes	DCN #

1 GENERAL

1.1 Scope

This document defines the Quality Assurance (QA) requirements for the establishment and implementation of QA programs for the Calorimeter covering mission definition, design, development, production and operations. For software quality assurance the software PA standard TBD is applicable.

2 APPLICABLE DOCUMENTS

2.1 Definitions

2.2 Abbreviations

3 QUALITY ASSURANCE PROGRAM MANAGEMENT

3.1 Quality Assurance Program

The Calorimeter shall implement a QA program whereby assurance is given that:

- All requirements are specified through definition and implementation of ad-equate methods and procedures.
- A set of design rules and methods has been set up and is consistent with the project techniques and technologies.
- Methods, procedures and tools have been defined and are implemented in order to prove that each applicable requirement is verified through one or more of the following methods: analysis, inspection, test, review of design, audits.
- For each configuration item there is a defined and implemented qualification approach that makes it possible to demonstrate that the item is so designed that it will perform satisfactorily in the intended environment.
- The approach adopted guarantees that the design is producible, repeatable, and verifiable and that the resulting product can be verified and operated within the required operating limits.
- Adequate controls verifiable by QA are established for the procurement of part components, materials, hardware items, and software.
- Fabrication, integration, test and maintenance are conducted in a controlled manner so that the end item conforms to the applicable approved procedures and test methods.
- All work is performed using the Calorimeter Work Order Authorization (WOA) database system and guidelines. A closed-loop nonconformance control system is established and maintained in order to systematically track and prevent reoccurrence. All work orders will be controlled and maintained by QA.
- Quality records are maintained and analyzed so that trends can be detected and reported in time to enable preventive/corrective actions to be taken using the work order database system.
- Equipment and tools used for inspecting, measuring and testing project items are regularly calibrated to ensure their accuracy.
- Procedures and instructions are established which provide for the identification, segregation, handling, packaging, preservation, storage and transportation of all items.
- Assurance is provided that the operations including post-flight and disposal are carried out in a controlled way and in accordance with the relevant requirements.

3.2 Organization

Calorimeter Quality Assurance Manager shall identify the personnel responsible for implementing and performing QA functions.

3.3 Quality Assurance Program Plan

The supplier, subcontractor, and collaborator shall prepare, maintain, and implement a plan of the QA activities, in accordance with the requirements in the MAR and will be submitted for approval. The plan may be part of the overall project Product Assurance Plan.

3.4 Quality Assurance Status Reporting

The supplier, subcontractor, and collaborator shall periodically prepare and submit to NRL, reports on the status and progress of the QA program, as part of the overall PA reporting.

3.5 Personnel Training and Certification

The supplier, subcontractor, and collaborator shall establish a documented training program for personnel whose performance determines or affects product quality. Operators performing critical processes shall be trained and certified by internal or external training programs accepted by NRL, or are able to demonstrate a regular and satisfactory use of the related skills.

3.6 Quality Assurance Program Audits

The NRL, supplier, subcontractor, and collaborator shall perform systematic audits on his own performance to verify the implementation and effectiveness of the provisions defined in the QA Program Plan for GLAST CAL. The supplier, subcontractor, and collaborator shall establish and maintain an audit plan for procurement activities on the project, designating the lower tier Suppliers to be audited, the current status and the schedule for auditing. NRL shall have the right to be represented in the planned external audits. For this purpose, the external audit schedule shall be supplied to NRL and updated regularly.

3.7 Quality Assurance Role in Configuration Management

Requirements for configuration and data management shall be clearly defined. The supplier, subcontractor, and collaborator shall ensure that configuration and data management rules are provided for, comply with those specified and are applied both by his own personnel and by his Suppliers' personnel. The NRL Quality Assurance manager shall attend all Boards established to review the suitability for release of drawings, plans, specifications, procedures and changes thereto. During the configuration verification process the 'as built' configuration of hardware and software shall be certified on the basis of the latest approved engineering data. QA's function shall ensure that:

a. The as designed status is defined prior to manufacturing.
b. The as-built documentation is properly defined, identified and maintained in order to reflect approved modifications.
c. Items to be delivered comply with the as-built documentation.

3.8 Process Control

The QA function shall contribute to the overall risk management activities by:

a. Supporting the identification and risk evaluation of critical items for which major difficulties or uncertainties are expected in:
   - Demonstration of design performances
   - Development and qualification of new product, processes and technologies
   - Procurement, manufacturing, assembly, inspection, test, handling, storage and transportation.
b. Contributing to the risk reduction plan by identifying the QA activities accompanying the individual risk reduction measures.
c. Monitoring and documenting the achievement of the specified risk reduction implementation and the corresponding verification measures throughout all project phases.

4 QUALITY ASSURANCE GENERAL REQUIREMENTS

4.1 Documentation and Data Control

QA function shall ensure that:

a. The pertinent issues of appropriate documents and data are available at all locations where operations essential to the effective functioning of the quality system are performed.
b. Invalid and/or obsolete documents and data are promptly removed from all points of issue or use, or otherwise assured against unintended use.
c. Any obsolete documents and data retained for legal and/or knowledge preservation purposes are suitably identified.
d. Proper data and documentation exchange procedures and formats are set up throughout the project organization.
e. The documents required by the business agreement are verified and signed by the designated people before release.
f. Documents are identified and verified for adequacy, currency and incorporation of Product Assurance requirements.
g. The need for document approval by Product Assurance is identified.
h. Changes to documents and data are reviewed and approved by the same functions organizations that performed the original review and approval unless specifically designated otherwise.
i. A master list or equivalent document control procedure identifying the current revision of documents and data support is established and is readily available to preclude the use of invalid and/or obsolete documents and data.

4.2 Quality Records

The NRL, supplier, subcontractor, and collaborator shall maintain quality records to provide objective evidence of complete and effective performance of QA tasks and to demonstrate achievement of the required quality using the work order system and proper signatures. Quality records shall be stored in safe conditions, which prevent alterations, loss or deterioration. NRL shall ensure that quality records are reviewed and delivered along with the hardware.

4.3 Traceability

4.3.1 General

a. The NRL, supplier, subcontractor, and collaborator shall implement a traceability system, which shall be maintained throughout all phases of the project and during the planned operational life of Calorimeter deliverable items.
b. The traceability system shall provide for the ability to:
    1. Establish bi-directional and unequivocal relationship between parts / materials / products and associated documentation / records.
    2. Trace data, personnel and equipment related to procurement, fabrication, inspection, test, assembly, integration and operations activities.
    3. Trace backwards the location of materials, parts, subassemblies.
    4. Trace forwards the location of materials from raw stock. Forward traceability may be required also for some critical items, as defined in the business agreement.
c. The level of traceability to be applied to an item shall be specified on engineering specifications, drawings and work orders.

4.3.2 Identification

a. Each part, material or product shall be identified by a unique and permanent part or type number.
b. In addition, parts, materials and products shall be identified as individual entities/ groups by means of one or more of the following methods:

1. Date codes indicating date of manufacture, to identify items made by a continuous process or subject to degradation with age.
2. Lot or batch numbers, to identify items produced in homogeneous groups and uniform conditions. This identification applies when the items are not required to be individually distinguishable.
3. Serial numbers, to identify individual items for which unique data are to be maintained.

c. Controls shall be established to ensure that:
   1. Identification numbers are assigned in a systematic and consecutive manner.
   2. Identification numbers of scrapped or destroyed items are not used again.
   3. Identification numbers, once allocated, are not changed, unless the change is authorized by the Customer.
d. Identification numbers shall be marked on documentation and, where possible, on respective items.
e. Method of marking on items shall be defined on engineering drawings, specifications, and work orders.
f. Method of marking shall be compatible with the nature of the item and its use.

4.3.3 Data Retrieval System

a. Documents and records shall be identified and linked to the respective items by means of their unique identification numbers.
b. The data retrieval system shall allow traceability starting from any point of the interconnected network existing between records, documents and marking on parts.

4.4 Metrology

The NRL, supplier, subcontractor, collaborator shall control, calibrate and maintain inspection, measuring and test equipment, whether owned by the NRL, supplier, subcontractor, collaborator, on loan, or provided by NRL to demonstrate the conformance of product to the specified requirements. Equipment shall be used in a manner, which ensures that measurement uncertainty is known and is consistent with the required measurement capability. All measurements shall take into account the total error in the measurement process attributable to the cumulative error from the calibration chain, measuring equipment and, as appropriate, those contributed by personnel, procedures and the environment. The basis for the calculation of the cumulative error shall be recorded. Corrective action shall be taken when the total error is such as to compromise significantly the ability to make measurements within the required accuracy and precision. The NRL, supplier, subcontractor, collaborator shall:

a. Identify the measurements to be made and the accuracy required and shall select the appropriate inspection, measuring and test equipment.
b. Identify, calibrate and adjust all inspection, measuring and test equipment and devices that can affect product quality at prescribed intervals, or prior to use, against certified equipment having a known valid relationship to nationally recognized standards; where no such standards exist, the bases used for calibration shall be documented.
c. Establish, document and maintain calibration procedures, including details of equipment type, identification number, location, frequency of checks, check method, acceptance criteria and the action to be taken when results are unsatisfactory.
d. Ensure that the inspection, measuring and test equipment is capable of the accuracy and precision necessary.
e. Identify inspection, measuring and test equipment with a suitable indicator or approved identification record to show the calibration status.
f. Maintain calibration records for inspection, measuring and test equipment.
g. Assess and document the validity of previous inspection and test results when inspection, measuring and test equipment is found to be out of calibration.
h. Ensure that the environmental conditions are suitable for the calibrations, inspections, measurements and tests being carried out.
i. Ensure that the handling, preservation and storage of inspection, measuring and test equipment is such that the accuracy and fitness for use is maintained.

j. Safeguard inspection, measuring and test facilities, including both test hardware and test software, from adjustments, which would invalidate the calibration setting.

Where test hardware (e.g. jigs, fixtures, templates, patterns) or test software is used as suitable forms of inspection, it shall be checked to prove that it is capable of verifying the acceptability of the product prior to release for use during production and installation and re-checked at prescribed intervals. The procedures shall establish the extent and frequency of such checks and shall maintain records as evidence of control.

Test aids, such as test leads, break-out boxes, mains leads and similar items are not subject to the entire set of requirements defined in this clause, but shall be validated in a way appropriate to their usage.

Measurement design data shall be made available, when required by NRL or his representative, for verification that it is functionally adequate.

4.5 Work Order Authorization (WOA) Database System

The purpose of the WOA database is to track the status of work orders and associated problem records. All information will be stored in the database linked to a unique work order authorization (WOA) number. Problem records written against the WOA are continually tracked to ensure a high level of product assurance. Real time user defined reports will be generated to display current status of each work order and problem records.

All work will be done on the CAL subsystem by an approved WOA. This work will include the engineering model, flight fabrication, integration, functional testing, trouble shooting, environmental tests, and shipping to SLAC. The WOA will specify the hardware items involved in the task, provide a brief description of the work to be performed, list the required documents, call out any hazards, and provide for the necessary approval signatures. The WOA form allows for short procedure steps to be included as part of the document in lieu of a separate formal procedure document. Attached procedures must be approved by the NRL I&T Manager, System Leads and QA.

The WOA flow diagram shown in Figure 1 illustrates the process and provides a way to plan the work and keep a record of the work being performed/completed on the satellite. A separate log will be maintained on a daily basis showing the status of all WOAs by WOA number and title. The WOA database will be maintained by a QA, including the log-in and sign-off of the work as completed. WOAs will be initiated by QA Subsystem Leads, Systems and the I&T Manager and NRL. WOAs must be approved by the subsystem manager, or delegated representative, Subsystems Lead, QA, and appropriate Subsystem Lead.

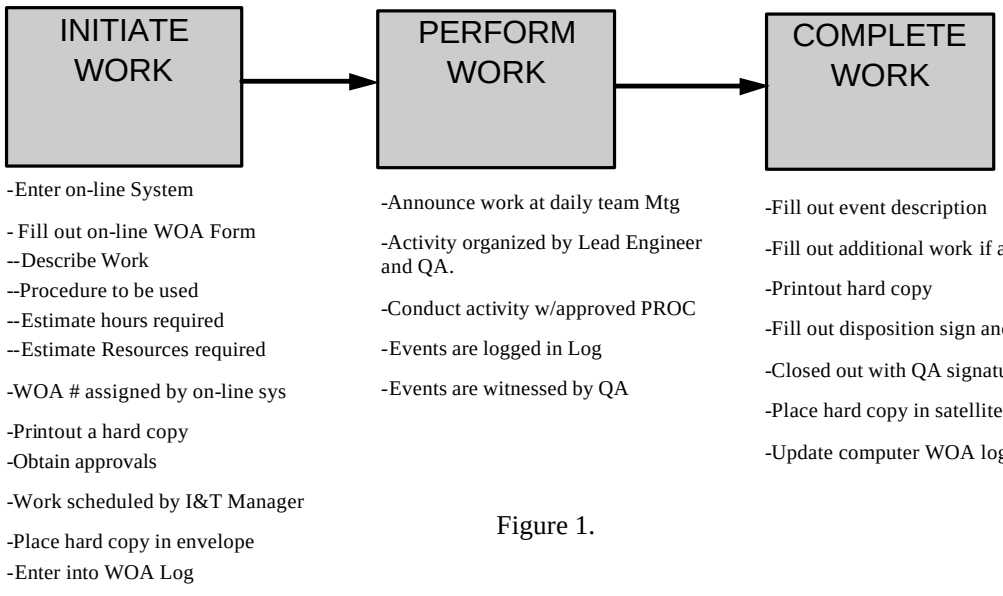

Figure 1.

The WOA system is a Microsoft Access 2000 database. The database file will reside on the NT Server. All users will be assigned a login username and password, which will determine their approval level. The computer requirements for using the WOA system are to have both Microsoft Access 2000 and a Microsoft Email Client (i.e. Outlook, Internet Mail, etc.) with valid user profile installed. A hard copy will be printed out at the initiator's request and the appropriate signatures will be obtained for approval. The hard copy will be the official document. The WOA log will be established and maintained by QA personnel. The QA functions to be provided for the WOA process are as follows:

Signature of approval on the WOA to perform the work/test
Maintain WOA status
Sign-off on WOA closeout
Maintain the WOA problem record status (see PR discussion below)

The following is a description of the information that shall be entered into the WOA form:

WOA Title:	A unique user assigned title to this work activity.
WOA No.:	A sequential number assigned by the database system.
Date of Request:	Current date
Expected End Date:	Anticipated completion date of this work activity.
Originator:	The person writing this WOA.
Responsible Person:	The person assigned responsibility to carry out this work order to completion (maybe the same person as the originator).
System/Subsystem:	i.e., mechanical, electrical, thermal,
Item Description:	Specific hardware items involved in work order activity
Brief Description of Work:	Briefly describe the work to be performed in general terms.
Required Documents:	List the documents required to perform this work order activity. These documents must be attached and accompany the WOA form.
Activity Level:	Check the box that indicates the hardware status level (Flight, Non-flight, or Other) on which the work will be performed.
Part Numbers:	List the major hardware part numbers involved in this activity.
Serial Numbers:	List the serial numbers for the major part numbers involved.
Approval Signatures:	These are the signatures that must be obtained in order to start the work activity. The approvals may be obtained on-line by way of the user login permission level or by hand.
Required Support:	The originator and quality assurance engineer must determine the level of QA support required. All flight work must have final QA inspection checked.
Configuration Mgmt:	This area will automatically indicate "OPEN" when a WOA is fully approved on-line. A "CLOSED" box will appear, at the time a WOA is open. The WOA can only be closed after all PRs associated with the subject WOA are closed out and a QA engineer approves closure.
Events:	List the detail procedure steps to be carried out in this WOA. All WOA event descriptions shall begin with:

10	NRL	Notify QA prior to work initiation
20	Electrical	Incorporate TBD
30	…	…
etc.	…	…
(and end with)		
XXX	QA	Quality Assurance Final Review

4.5.1 Anomaly and Failure Reports

All test failures of flight hardware will be documented with a PR. The PRs are used to document and track single anomalous events and their resolution. The I&T Manager, supported by the Core Team, will

periodically review outstanding PRs, maintain report files and present status. A review will be conducted on the resolution of all flight hardware anomalies.

The database will provide a tracking system for assigning numbers, and for logging and reporting the status of the anomaly.

4.5.2 Problem Record (PR)

Anomalies are reported on a PR and will be used to record all in process problems. The problem/anomaly is any unexpected occurrence in the operation of a test that could have resulted from a glitch or failure due to GSE malfunction, a cable/connector interruption, a software anomaly, or a hardware anomaly. The PR form is created in the WOA database system. The responsible person shall enter all problems into the database as they occur. The WOA database tracks open PRs and provides a controlled method of closure by a QA engineer. A hard copy of this form will be put in the calorimeter logbook and is the official document. The lead subsystem engineer, is responsible for tracking each anomaly (PR) to resolution and reporting its status to the QA and subsystem manager. Close out of PRs require approval by the Subsystem Manager, Systems Engineering, Systems Leads and QA.

Problems may be put into two classifications, Class 1 requires a PR to be generated and Class 2 problems generally will not require a PR to be generated. The criteria for entering a problem into the PR system is based on the following:

Class 1 - Class 1 problems will be entered as a reportable PR if the problem has to be deferred for resolution or if the problem affects the interface, form, fit, or function.

Class 2 - Class 2 problems are generally minor deviations that can be taken care of in real-time as part of the WOA procedure process. All problems must be recorded on the WOA and initialed by QA. Some judgment must be exercised here since this could be a repeating problem that will need to be dealt with in another WOA and therefore should be categorized as a Class 1 problem. Documents that are redlined during this process will become a permanent part of the “as built” record. These changes may not need to be put into the PR system as a trackable problem but redlined changes to a CM drawing or procedure will require a revision after the test activities are finished for an official change notice.

4.6 Nonconformance Control System

The NRL, supplier, subcontractor, collaborator shall establish and maintain a nonconformance control system. The system shall provide for a disciplined approach to the identification and segregation of nonconforming items, the recording, reporting, review, disposition and the definition and implementation of corrective actions. Nonconformances or Problem Reports shall be classified as red (major), yellow (minor) or green (none) on the basis of the severity of their consequences.

Major nonconformances mark as red in the work order database system shall be those, which may have an impact on the requirements in the following areas:

a. Safety of people or equipment;
b. Operational, functional or contractual requirements;
c. Reliability, maintainability, availability;
d. Lifetime;
e. Functional or dimensional interchangeability;
f. Interfaces with hardware and/or software of different contractual responsibility. Additionally, any nonconformances shall be classified as major in the cases of:
g. Incorrect qualification or acceptance test procedures or noncompliant test results;
h. For EEE components, the
   - Lot/batch rejection during manufacturing, screening or testing at the manufacturer’s facilities, if:
     1. Use-as-is of the the rejected lot/batch is proposed, or
   - Any nonconformances after delivery from the manufacturer. The following discrepancies at incoming inspection may be classified as minor, marked in yellow in the work order database system.

1. Random failures, where no risk for a lot-related reliability or quality problem exists;
2. The form, fit or function are not affected;
3. Minor inconsistencies in the accompanying documentation.

NOTE: Minor nonconformances are those, which by definition cannot be classified as major.

The consequences of several different nonconformances on the same item shall be evaluated. Nonconformances shall be reviewed and dispositioned by a formal Material Review Board (MRB) headed by NRL QA.

All nonconformances/problem reports shall be reviewed to identify the root causes, and implement corrective actions to prevent recurrence.

4.7 Handling, Storage, Preservation

4.7.1 Handling

a. The NRL, supplier, subcontractor, collaborator shall prevent handling damage during all phases of manufacturing, assembly, integration, testing, storage, transportation and operation, by adequate:
   1. Protection of items during handling;
   2. Handling devices;
   3. Procedures and instructions.

Detailed requirements for handling of hardware shall be defined in the relevant procedures or on the work order.

4.7.2 Storage

a. The NRL, supplier, subcontractor, collaborator shall have secure storage areas available for:
   1. Incoming materials;
   2. Intermediate items needing temporary storage;
   3. End items before shipping.
b. Limited-life materials, suspended limited-life material, nonconforming items, scrap items and all other items, which require to be stored separately.
c. Each segregated area within the stores shall be clearly identified and labeled.
d. Controls shall be maintained over the acceptance into and withdrawal from the storage area.
e. Records shall be maintained to ensure that all stored items are within the usable life limits and adequately controlled and retested, and to provide trace-ability within the storage area.

Detailed requirements for storage shall be defined in the relevant procedures or on the work order.

4.7.3 Preservation

The NRL, supplier, subcontractor, collaborator shall ensure that items subject to deterioration, corrosion or contamination through exposure to air, moisture or other environmental elements are preserved by methods, which ensure maximum protection consistent with life and usage.

Detailed requirements for preservation shall be defined in the relevant procedures or on the work order.

5 QA REQUIREMENTS FOR DESIGN AND VERIFICATION

5.1 General

In support of the MAR requirements, NRL's QA function is intended to assure that:

- Design and operational requirements are specified in terms of quantity and/or quality, clearly expressed and consistent.
- The design definition is expressed for each Configuration Item in a way, which ensures compatibility of Configuration Items among themselves and with system requirements.

- NRL requirements are understood and taken into account by the functions involved and any deviation properly resolved with the customer.
- Methods, data and means (including software) required for each activity are developed, available and validated.
- All technical risks are identified and provisions for their reduction are implemented.

5.2 Planning

The NRL, supplier, subcontractor, collaborator shall implement a QA program to assure that:

a. Design and verification activities are planned in a consistent and logical way.
b. Critical processes and new technologies are identified in a timely manner and adequate evaluation and/or qualification activities are implemented in line with the overall schedule.
c. Significant deviations from the agreed planning and their consequences are evaluated and accepted by the authorized person responsible and/or the Customer prior to implementation, and the affected documentation is updated.
d. The verification process is adequate (in particular: clear test, test model and verification philosophy).

5.3 Organizational and Technical Interfaces

The NRL, supplier, subcontractor, collaborator shall implement a QA program to assure that:

a. Interfaces between different groups, which provide input to the design and verification process are defined and supported.
b. Incomplete, ambiguous or conflicting requirements shall be resolved with those responsible for imposing these requirements.
c. Feedback information is maintained from production, test, product assurance, operations, towards design implementation.
d. Methods and procedures are established to ensure that the experience gained in present and past activities is systematically incorporated into design construction.

5.4 Design Rules

5.4.1 General

The NRL, supplier, subcontractor, collaborator shall ensure that the design rules and guidelines defined below are properly implemented in the design.

5.4.2 Produceability

a. The product shall be so designed that it can be produced in an efficient manner with the required level of quality.
b. Design rules and guidelines shall include provisions for the following aspects:

    1. Guidelines for selection of preferred parts, materials and processes.
    2. All necessary requirements and limits shall be defined, so as to avoid individual interpretation.
    3. Tolerance build–up methods shall be defined, in order to simplify manufacturing, assembly, inspection.
    4. Standardization of interfaces, wherever possible.
    5. Part accessibility for assembly and inspection.
    6. Definition of design criteria, which are consistent with the capability of manufacturing processes.
    7. Definition of proper design methods to ensure the achievement of cleanliness objectives, compatible with the capability of related cleanliness procedures and facilities.

5.4.3 Repeatability

a. The product shall be so designed that its performances and characteristics can be reproduced.
b. Design rules and guidelines shall include provisions for the following aspects:

    1. Definition of standard tolerances generally applicable, unless more stringent values are specifically required.
    2. Recommended manufacturing processes having proven repeatability.
    3. Design criteria which optimize implementation of automated manufacturing methods, or computer–aided manufacturing.

5.4.4 Inspectability and Testability

a. The product shall be so designed that it can be easily and efficiently inspected and tested under representative conditions, for production, AIV and operational environment.
b. Design rules and guidelines shall include provisions for the following aspects:

    1. Inspection and test requirements, including acceptance/reject criteria, shall be defined, and expressed in an unambiguous and quantified manner.
    2. Part and component accessibility shall be ensured for inspection and test.
    3. Tolerance methods that ease dimensional inspection performance (such as functional tolerances) shall be defined.
    4. Recommended design techniques shall be defined as a means of facilitating fault detection, identification and location (such as: test points, modularity, built-in test software, feedback loops, ...).

5.5 Standards and Procedures

The NRL, supplier, subcontractor, collaborator shall establish and maintain design standards and procedures for the preparation and maintenance of engineering drawings and specifications. Standards and procedures shall include provisions for the following aspects:

a. Requirements shall be clearly expressed and consistent.
b. Critical items shall be identified on technical documents.
c. Technical documents shall specify:
    - Functional performances and operational requirements including depend-ability and safety requirements;
    - Applicable design and construction requirements proper to ensure produce-ability, repeatability, testability and operability of the product;
    - Required verifications methods as review of design, analysis, inspection or tests, including acceptance/reject criteria;
    - Reference to process and material specifications;
    - Identification methods;
    - Marking method and position;
    - Required cleanliness levels.
d. Physical and functional tolerances shall be always defined, and controlled to avoid the use of irrational limits and to ensure interchangeability.

5.6 Verification

5.6.1 General

The NRL, supplier, subcontractor, collaborator shall implement a QA program to assure that satisfactory provisions are defined and implemented in order to verify that the requirements are meet, specifically:

a. Requirement verification is performed progressively, as each stage of the manufacturing is completed, and provides the organized base of data upon which qualification and acceptance will be incrementally declared.

b. Top–down requirement allocations and bottom-up requirement verifications are complete and consistent.
c. A system for tracking requirements and verification of results is established and maintained during the completion of the CAL project.
d. Verification methods are adequate and consistent with the type and criticality of the requirements.
e. Appropriate reference to the verification documentation is recorded and status updated at project reviews up to final acceptance.

5.6.2 Design Verification Analysis

a. The NRL, supplier, subcontractor, collaborator shall implement a QA program to assure that the objectives of the analysis are clearly defined in relation with the development logic defined in the verification plan.
b. The following items shall be identified:
   - Reference of the Configuration Item definition under analysis.
   - Environmental constraints considered in the analysis.
   - Basic assumptions, analysis methods, mathematical models.

5.6.3 Design Reviews

The NRL, supplier, subcontractor, collaborator shall ensure that:

1. Quality requirements and criteria for design, produceability, repeatability and testability are adequately considered in design documentation.
2. Methods and data required for procurement, manufacturing, inspection and test are available and validated.
3. Risks of not achieving requirements are highlighted and adequately con-trolled.

5.6.4 Qualification Process

5.6.4.1 Qualification

The NRL, supplier, subcontractor, collaborator shall implement a QA program to assure that all Configuration Items and their constituent items, as defined in the relevant procedure for the part/component/assembly under consideration.

5.6.4.2 Qualification Testing

a. The product used for Qualification testing shall be produced in accordance with a full and clearly identified and approved procedures, processes, and manufacturing and inspection methods.
b. To obtain authorization to initiate qualification tests the Supplier shall demonstrate that:

   1. The qualification model is fully representative of the flight model and any differences have been analyzed to evaluate their effect on the qualification status.
   2. Inspection and test requirements are expressed in an unambiguous and quantified manner including:
      - test sequence;
      - test conditions;
      - test standards, if any;
      - applicable test levels, duration and tolerances;
      - accuracy in measurement.
   3. The qualification test procedures and facilities are defined, approved, and released.

5.6.4.3 Qualification Status Reporting

a. The NRL, supplier, subcontractor, collaborator shall track, record and periodically report to the Customer, the qualification status of all deliverable items as well the progress of the qualification program.

b. Lists showing qualification status of items shall be made available at the various project reviews.

5.6.4.4 Maintenance of Qualification

Once the design has been qualified, all subsequent changes, deviations and anomalies shall be reviewed for their impact on the qualification status and re-qualified as necessary.

5.7 Design Changes

The NRL, supplier, subcontractor, collaborator shall implement a QA program to assure that all design changes and modifications are identified, documented, reviewed and approved before their implementation.

6 QA REQUIREMENTS FOR PROCUREMENT

6.1 General

The NRL, supplier, subcontractor, collaborator shall control the procurement activity to ensure that all items and services procured conform to requirements. The control of procurement activity includes selection of procurement sources, control of purchase documents, surveillance of lower tier Suppliers (where applicable) and control of incoming items.

6.2 Selection of Procurement Sources

6.2.1 General

The NRL Quality Assurance organization shall participate in and approve the selection of procurement sources when and where required.

6.2.2 Selection Criteria

a. The NRL, supplier, subcontractor, collaborator shall select its Suppliers on the basis of one of the following criteria:
    1. The Supplier has been certified and has a current approval to furnish items or services of the type and quality level being pro-cured.
    2. The Supplier is furnishing, or has furnished within the past two years, items or services of the type and quality level being procured under other contracts.
    3. The Supplier has demonstrated continuous capability to furnish items or services of the type and quality level being procured. This capability shall be supported by objective documentation. This criterion shall not apply if the Supplier has not furnished items or services of the type being procured for more than two years.
    4. Supplier's capability requirement is demonstrated by a pre-award audit by the NRL QA. The results of pre-award audits shall be documented and maintained on file.

b. Due consideration shall be given to a third party certification against ISO 9001, ISO 9002 and ISO 90003, as appropriate to the nature of the products to be procured.

c. The selection of procurement sources for EEE components shall be in accordance with NASA/GSFC NSPL and as defined in the EEE parts plan.

6.2.3 Record and List of Procurement Sources

a. NRL shall establish and maintain records of all procurement sources involved in business agreement performance.

b. The NRL, supplier, subcontractor, collaborator shall submit to NRL, upon request, the list of procurement sources, including all the information in the records above, for information.

6.3 Procurement Documents

The Supplier shall ensure that items to be procured are precisely identified and all applicable requirements are properly defined in the procurement documents.

The procurement documents shall contain, by statement or reference:

a. Comprehensive technical descriptions of the items and services to be procured.
b. Details of the applicable requirements, such as requirements for preservation, packaging, marking, shipping, accompanying documentation and provisions for limited–life items.
c. Details of QA activities to be performed, such as inspection and test characteristics, records and reports.
d. Special acceptance conditions.

6.4 Surveillance of Procurement Sources

NRL shall exercise surveillance over all the activities carried out by his suppliers/subcontractors during performance of the task.

The surveillance program shall include, to the extent appropriate, audits, reviews (e.g. Manufacturing Readiness Review), Mandatory Inspection Points, as well as direct supervision by resident QA.

6.5 Receiving Inspection

6.5.1 General

a. The NRL shall take appropriate actions to ensure that all incoming supplies, including documentation and packaging, whether delivered on his own premises or elsewhere, conform to the requirements of the procurement documents.
b. Inspections shall be performed in accordance with established procedures and instructions, to ensure that quality level is properly determined.
c. Receiving inspectors shall have available the procurement documents, specifications, drawings and any other document relevant to incoming materials.

6.5.2 Receiving Inspection Activities

Receiving inspection activities shall include:

a. Verification of the packaging conditions and of the status of environmental sensors.
b. Visual inspection of the delivered items.
c. Verification of correct identification and, where appropriate, configuration identification for conformance to the ordering data.
d. Verification of the evidence of inspection and tests performed by the Supplier and associated documentation.
e. Verification of the performance of inspection, when required.
f. Performance of inspection and tests on selected characteristics of incoming materials.
g. Identification of the shelf life of limited life items.
h. Identification of the inspection status and physical separation of the supplies in the receiving inspection area according to the following categories:

    - Items for which the receiving inspection has not be completed;
    - Conforming Items;
    - Nonconforming Items.

i. Prevention of unauthorized use of un-inspected items.
j. Identification of the items to be released for production with conformance status and traceability data to be recorded in manufacturing documents.
k. Maintenance of Receiving Inspection Records.

6.5.3 Customer Furnished Items

a. Receiving inspection of items supplied by the Customer shall consist, as a minimum, of the verification of identity and integrity after transportation.
b. Additional inspections and tests shall be as specified in the business agreement or in the procedures.

6.5.4 Receiving Inspection Records

Incoming inspection records shall be maintained to ensure traceability and the availability of data.

7 QA REQUIREMENTS FOR MANUFACTURING, ASSEMBLY AND INTEGRATION

7.1 General

The NRL shall ensure that the deliverables are built, assembled and integrated to the approved configuration procedures and processes in a planned, controlled and reproducible manner.

7.2 Planning of Manufacturing, Assembly, and Integration Activities and Associated Documents

NRL, after a complete review of all requirements defined by the design and engineering documentation, shall plan manufacturing, assembly and integration operations in coordination with QA and tests.

The planning of manufacturing, assembly and integration operations and inspections shall be reflected in flow charts for the item, which shall clearly depict the sequence of operations and associated inspections and tests. It shall include the identification of MIPs, together with the reference to the procedures by which the various activities are to be performed and the required cleanliness levels of facilities.

Adequate instructions, defined on the approved work orders, shall direct the actual performance of manufacturing, assembly and integration operations and inspections, to ensure that the activities proceed in an orderly manner and according to the planned sequence.

Manufacturing, assembly and integration documents shall be issued and maintained in accordance with established and formal procedures.

The Quality Assurance function shall review and approve work orders, such documents, and any modifications thereof, to ensure that they include or refer to:

a. Identification of the item to be manufactured or equipment to be used.
b. Configuration data, including parts lists, drawings, changes and specifications.
c. Identification of the production and inspection equipment (tools, jigs, fixtures ...) to be used for the manufacturing, assembly and integration of the item.
d. Identification of critical characteristics.
e. Detailed definition, by description or reference, of manufacturing, assembly, integration, inspections and test operations to be performed, and special conditions to be maintained.
f. Provisions for inspections and tests to be witnessed by customer representative.
g. Accept/reject criteria (with tolerances) and workmanship standards.
h. Detailed procedures for the activities to be performed.

NRL shall also provide for detail support documents and instructions, such as operation drawings and operation instruction sheets, to enable operations to be correctly performed.

7.3 Manufacturing Readiness Review

The Supplier shall perform an internal review of the readiness for manufacturing, prior to start the manufacturing of the first flight and flight like item or product. The Manufacturing Readiness Review shall evaluate systematically the following aspects:

a. Status of product definition and requirements, differences with the status of the engineering model, qualification model, and impacts of these differences.
b. Status of manufacturing, assembly, inspection and test documentation, differences with the status of the engineering model, qualification model, and impacts of these differences.

c. Validation status of manufacturing processes, with particular emphasis on critical processes.
d. Implementation of adequate dispositions for risk reduction, as defined by risk assessment, into the manufacturing, assembly, integration, inspection and test procedures.
e. Availability of required production, measuring and inspection equipment, and calibration status, when relevant.
f. Cleanliness of facilities, with respect to the required cleanliness levels.

7.4 Control of Processes

a. NRL shall monitor all processes used for manufacturing, assembly and integration, and shall enforce all applicable process requirements.
b. All manufacturing processes shall be covered by documented approved process specifications.
c. Process specifications shall include QA provisions, methods for inspection and test, number of samples, accept/reject criteria.
d. Process witness samples shall be stored in proper conditions along with the test data.
e. Personnel who perform critical processes or evaluate the process performance are trained and certified and/or can demonstrate their proficiency through their regular activity.
f. Materials, equipment, computer systems and software, and procedures involved are validated and monitored.

7.5 Workmanship Standards

The NRL, supplier, subcontractor, collaborator shall employ workmanship standards, methods, or approved procedures throughout all phases of manufacturing, assembly and integration, to ensure acceptable and consistent workmanship quality levels. Documentary workmanship specifications shall identify definite acceptance/rejection criteria.

7.6 Materials and Parts Control

The NRL, supplier, subcontractor, collaborator shall ensure that only conforming items are released and used, and that those not required for the operation involved are removed from work operation areas. Items having limited life or definite characteristics of quality degradation or drift with age and/or use shall be marked to indicate the dates, test times or cycles at which life was initiated and at which the useful life will expire. Sensitive items such as crystals, CDEs, etc., shall be processed or manufactured, inspected and tested in a con-trolled environment to prevent any degradation.

7.7 Equipment Control

a. The NRL, supplier, subcontractor, collaborator shall make provisions for accountability, identification and maintenance of manufacture, assembly and integration tooling.
b. Manufacture, assembly and integration tooling shall be checked for its dimensional accuracy, regarding the product drawings, and correct function.
c. Tooling shall be approved by the Quality Assurance organization prior to use. The approval shall be stamped or labeled on the equipment and recorded.
d. Tools shall be checked for accuracy during the production life at adequate intervals.
e. Tools shall be submitted to re-approval following modification.
f. Tools shall be properly stored to prevent misuse, damage and deterioration.
g. Unnecessary tools shall be removed from working areas.
h. Records shall be kept of all manufacture equipment.

7.8 Cleanliness and Contamination Control

a. The NRL, supplier, subcontractor, collaborator shall establish controls for molecular and particulate cleanliness of spacecraft hardware and facilities, and the limitation of sources of contamination as defined in the CAL Contamination Control Plan, LAT-MD-00228.
b. The controls to be applied shall be defined in a Cleanliness and Contamination Control Plan.
c. The NRL, supplier, subcontractor, collaborator shall develop detailed methods for attaining the cleanliness levels required for the hardware.

7.9 Inspection

QA Inspection and tests shall be planned at the points of the manufacturing, assembly and integration flow. Self-inspection by the operators performing the associated manufacturing, assembly and integration activities shall not be considered sufficient for critical characteristics. Among the inspections and tests as part of the manufacturing, assembly and integration flow, some selected inspections, called MIPs (Mandatory Inspection Points) shall be performed with participation of NRL QA and other representatives. MIPs shall be agreed with the NRL QA and Customer.

An MIP shall require an invitation with the agreed notice before the event, and the participation of the Customer, NRL QA, or their written agreement to proceed without their participation. All flight hardware shall have a positive identification of the inspection and test status of any items at any stage of the manufacturing, assembly and integration cycle, starting from the incoming inspection up to shipping of the end item.

7.10 Specific Requirements for Assembly and Integration

7.10.1 Control of Temporary Installations and Removals

a. The NRL, supplier, subcontractor, collaborator shall ensure the management and control of flight items, which are temporarily removed or non-flight items, which are temporarily installed to facilitate assembly, integration, testing, handling or preservation of the end item.
b. The control shall be initiated upon installation or removal of the first temporarily installed or removed item and shall be maintained through delivery and use of the end item.
c. Records of temporary installations and removals shall be established and maintained.
d. Temporarily installed items shall be accounted for to prevent their being incorporated in the final flight configuration.

7.10.2 Logbooks

a. The NRL, supplier, subcontractor, collaborator shall prepare and maintain subsystem and equipment logbooks using work order database system for all operations and tests per-formed on the item during the period to be covered by the logbook.
b. Equipment logbooks shall start with the first qualification or acceptance test after assembly.
c. Subsystem logbooks shall follow-on from the individual equipment logbooks to form a full record.
d. The logbook shall accompany the CAL hardware whenever it is placed in the custody of another organization and this organization shall update it.
e. The logbooks shall contain historical and quality data and information, which is significant for operation of the item, including problem reports, nonconformances, deviations and open tasks on work orders.

7.11 Manufacturing, Assembly, and Integration Records

Manufacturing, assembly and integration records shall be established and maintained, to provide all manufacturing, assembly, integration and inspection data required for traceability.

8 TESTING

8.1 Test Facilities

The NRL, supplier, subcontractor, collaborator shall ensure that test facilities, either internal or external, comply with TBD.

8.2 Test Equipment

It shall be possible to verify the correct operation of all items of test equipment without having to apply them to the test item.

8.3 Test Documentation

8.3.1 Test Procedures

a. The NRL, supplier, subcontractor, collaborator shall implement a QA program to assure that tests are performed in accordance with documented and approved work orders and procedures, which shall include, as a minimum:

1. Scope of the test, including the identification of the requirement being verified;
2. Identification of the test object;
3. Applicable documents, with their revision status;
4. Test flow;
5. Test organization;
6. Test conditions;
7. Test equipment and set-up;
8. Step-by-step procedure, including definition of specific steps to be witnessed by QA personnel;
9. Recording of data;
10. Pass/fail criteria and test data evaluation requirements;
11. Guidelines / criteria for deviation from test procedure and for retest.

b. Test procedures and reports shall be reviewed and approved by the QA function.

8.3.2 Test Reports

The NRL, supplier, subcontractor, collaborator shall ensure that all test are comprehensively documented in test reports, and that they include, as a minimum:

a. Reference to the applicable test procedure, and description of the deviations from it during the actual testing.
b. Test data records and evaluation.
c. Summary of test results.

8.4 Test Performance Monitoring

On the basis of an analysis of the Test Plan, the QA function shall define within the Test Plan the most appropriate way to monitor the performance of test activities, to ensure the adherence to the test procedures, and that any deviations are properly documented and treated.

All testing activities related to critical characteristics as identified in the critical items control program shall be certified. Self-certification by the operators performing the test activities shall not be considered sufficient for critical characteristics. Testing activities and results to be subject to formal QA certification shall be identified as such in the relevant test procedure.

Where safety of personnel or damage to items or associated test equipment is possible, QA personnel shall be given direct authority to stop the test or shall give immediate access to anyone who holds such authority.

8.5 Test Reviews

NRL shall implement a QA program to assure that formal reviews are performed before and after major portions of qualification or acceptance tests. The QA function shall be represented in the formal boards established for the re-view of readiness for testing and testing accomplishment.

9 QA REQUIREMENTS FOR ACCEPTANCE AND DELIVERY

9.1 General

The NRL, supplier, subcontractor, collaborator shall establish a formal acceptance process for all deliverable items, at any contractual level, to ensure that conformance of the items to be delivered is fully assessed and documented. The NRL, supplier, subcontractor, collaborator shall also ensure that the preparation of the items for delivery and the physical delivery itself are performed in such a way that quality degradation is prevented.

9.2 Acceptance Data Package

The NRL, supplier, subcontractor, collaborator shall provide an End Item Data Package (EIDP) for each deliverable end item. The EIDP shall constitute the basis for formal acceptance reviews. The EIDP shall include the set of work orders, documents and records for further integration, testing and operation in higher level assemblies. EIDPs shall be maintained and integrated into higher level EIDPs during LAT integration and testing.

9.3 Delivery Review Board (DRB)

The NRL, supplier, subcontractor, collaborator shall ensure that a DRB is convened prior to the delivery of equipments, separately assembled subsystems or test/handling equipment for higher level activities.

The DRB functions at subsystem level shall be fulfilled by the final acceptance review. The DRB shall be composed, at least, of the following members:

a. Representatives of the receiving organization:

- Project Manager, or authorized representative, as chairman.
- QA Manager
- Subsystem Manager, or authorized representative.

b. Submitting representatives:

- Project Manager, or authorized representative.
- QA Manager, or authorized representative.
- Engineering/Design Manager, or authorized representative.

9.4 Preparation for Delivery

9.4.1 Packaging

The NRL, supplier, subcontractor, collaborator shall ensure that packaging materials, methods, procedures and instructions provide for protection of items during transportation and as far as is practicable after arrival at destination.

9.4.2 Marking and Labeling

The NRL, supplier, subcontractor, collaborator shall ensure that appropriate marking and labeling for packaging, storage, transportation and shipping of items are performed in accordance with the applicable specifications.

9.5 Delivery

9.5.1 Shipping Control

The NRL, supplier, subcontractor, collaborator shall ensure that the items to be shipped from his plant are inspected before release and found to be complete, adequately preserved and packaged, correctly marked and accompanied by all the required documentation. Accompanying documentation shall include the EIDP along with the shipping container, the handling and packing/unpacking procedure and any relevant safety procedures.

10 QA REQUIREMENTS

10.1 QA Plan for Operations

The NRL, supplier, subcontractor, collaborator shall prepare, maintain and implement a QA Plan for operations or for major phases of the operations to describe how all QA applicable requirements will be implemented.

For all operational phases or subphases having different features, different hazards and different critical operational requirements, the QA Plan shall highlight those specific features and identify which corresponding QA provisions are made in order to satisfy mission requirements and minimize associated risks.

10.2 Operations Planning

The NRL, supplier, subcontractor, collaborator shall implement a QA program to assure that operations are carried out in accordance with a planned and demonstrated process, and that all elementary operations including back–up operations, especially the critical ones (time critical, safety critical...), are covered by written procedures.

10.3 Operational Demonstration

a. The NRL, supplier, subcontractor, collaborator shall assure that a demonstration of the operational ability has been achieved prior to the start of an operational phase, through simulations of operations in a sufficiently representative environment, with regard to:

    1. Physical environment:
    2. Configuration of flight and ground segments, including hardware, soft-ware, databases;
    3. Sequence of operations;
    4. Operational procedures and associated tools;
    5. Operators.

b. Major deviations from the operational environment shall be assessed for the impacts on the validity of the conclusions of the demonstration.

c. Demonstration of the operational ability shall specifically include:

    1. Maintainability / availability;
    2. Safety/human interface;
    3. Environment;
    4. Cleanliness;
    5. Ability to supply products or services meeting quality requirements.

d. Where an operational phase or subphase includes critical operations (safety, mission...), the related critical operations or all the operational phase or sub-phase demonstrations shall be approved.

e. When the operational environment changes, the need to reperform the demonstration of operational ability shall be assessed.

10.4 Training and Operator Certification

a. The NRL, supplier, subcontractor, collaborator shall identify areas requiring training and operator certification for the operational phase.

b. Training shall be performed in an environment recognized as sufficiently representative of the real operational configuration.

c. When the operational environment changes, the need for additional training shall be assessed.

10.5 Operations Anomalies and Feedback Corrective Loop

a. The NRL, supplier, subcontractor, collaborator shall establish and maintain a documented system for the control of all nonconformances and anomalies detected at any stage during operations, and regarding:

    1. The Calorimeter;
    2. operational documents and data;
    3. facilities, hardware and software related to operations;
    4. human errors;
    5. end product and services;
    6. complaints of final customer and users.

b. The system shall provide for an effective feedback loop to prevent recurrence. In general, the established system for the handling of any anomaly shall comply with the requirements.
c. Competent and authorized personnel from quality assurance, engineering and operations shall be available and support the MRB functions in close cooperation with the flight control, training, mission centers as appropriate.

10.6 Alerts

Identified anomalies likely to recur during similar space missions shall be reported in compliance with the provisions defined herein.

10.7 Procedural Deviations

a. The QA function shall verify that deviations from nominal procedures defined in relevant documents such as user manuals, operations procedures and other operations-supporting documents are duly justified, documented and validated before application.
b. Deviations from the nominal procedures shall be validated prior to application.
c. When changes to procedures are implemented without validation, the QA function shall ensure that these changes have no impacts on the space segments safety and/or reliability or on the mission product quality.
d. Implementation of contingency procedures to meet an urgent safety demand, not identified by the initial operational procedures, shall be documented and traceable.

10.8 General Requirements

The following requirements shall be applied:

a. Cleanliness and Contamination Control
b. Testing
c. Acceptance and delivery
d. Traceability

APPENDIX A
GROUND SUPPORT EQUIPMENT (GSE)

General

Ground Support Equipment (GSE) is clarified as: "Optical, mechanical, fluidic, electrical and software support equipment or systems used for calibration, measurements, testing, simulation, transportation, handling... of space segment or of space segment elements."

Development

Design Quality Requirements for GSE

Design Quality requirements are strongly linked to the function to be implemented by the GSE item. Nevertheless, the following requirements will generally apply:

- Testability
- Availability (Reliability plus Maintainability)
- Safety
- Life duration
- Operability (Man/Machine Interface, completeness and clarity of operational procedures and manuals
- Ability to interface as necessary with space segment in a safe way.

Design and Verification

The Supplier shall implement a QA program to assure that:

1. Internal design and verification standards are used or developed corresponding with the techniques to be used and fitting with the level of complexity of the items to be developed.
2. Major development risks are identified and appropriate back–up solutions are foreseen.
3. The verification method and process are tailored to:

    i. the complexity of the item to be verified;
    ii. the criticality of the function to be implemented by the GSE item;
    iii. the inherent criticality of the item itself.

As a minimum, all GSE requirements, which affect the interface to flight hardware or affect safety shall be verified.

Configuration Control

The Supplier shall implement a QA program to assure that a Configuration Control function is implemented covering all elements of the GSE, and allows, as a minimum:

a. To identify the baseline documentation and product definition associated with formal contractual milestones;
b. To trace subsequent modifications when affecting contractual requirements.

Production

Procurement

The Supplier shall ensure that selected Suppliers have a demonstrated ability to perform satisfactorily, through:

1. previous supply of items similar or more complex in the same field of techniques and technologies; and/or
2. certification covering similar design, development and production as applicable for similar items; and/or
3. evidence, documented by existing design, development, production and quality standards, of having similar experience associated with known success.

Procurement documents shall clearly identify qualification and receiving inspection requirements as appropriate, and comply with the requirements herein.

Manufacturing, Assembly, Integration, and Test

As a minimum, ISO 9002 requirements should be satisfied. Unless proven necessary, the Supplier and his lower tier Suppliers should not deviate from their standard practices when these are already documented and recognized for similar items.

Delivery Phase

Acceptance of Data Package

The Acceptance Data Package shall contain as a minimum:

a. the information regarding interfaces;
b. deviations from contractual requirements;
c. certification of conformance to an identified baseline;
d. data necessary to understand the functioning of the item, and to operate and maintain it in a safe and easy way;
e. safety data and/or certification(s).

Acceptance

a. Acceptance shall be achieved through a formal review process.
b. The acceptance process shall include:

    1. acceptance plan;
    2. necessary inspection and test procedures;
    3. comprehensive inspection and test reports.
    4. Acceptance may be through a simple inspection process for simple items.

Delivery Board

a. Acceptance of major elements of the GSE shall be granted by a Delivery Board.
b. The Delivery Board shall include QA representatives from the Supplier and the Customer.

Delivery

The requirements of the following sub–clauses are applicable to the delivery of ground items and handling, storage, packing and shipping activities:

a. Preparation for delivery
b. Delivery
c. Handling, storage, presentation

General Requirements

The following requirements shall be tailored in accordance with the complexity and criticality of the GSE item:

a. Documentation and data control
b. Traceability
c. Metrology and calibration
d. Nonconformance control system

Maintenance

a. Maintenance activities shall be planned.
b. Maintenance demonstration shall be performed in order to prove that maintainability requirements are satisfied in the real operational environment.